Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices

SHOUT
SHARE
IT

HAWAII AGRICULTURAL EXPERIMENT STATION
HONOLULU, HAWAII
BULLETIN No. 49

Under the supervision of the
UNITED STATES DEPARTMENT OF AGRICULTURE

ARY
1923
Agriculture

THE ACID LIME FRUIT IN HAWAII

BY

W. T. POPE, Horticulturist

Issued July 9, 1923

WASHINGTON
GOVERNMENT PRINTING OFFICE
1923

HAWAII AGRICULTURAL EXPERIMENT STATION

HONOLULU, HAWAII

BULLETIN No. 49

Under the supervision of the
UNITED STATES DEPARTMENT OF AGRICULTURE

THE ACID LIME FRUIT IN HAWAII

BY

W. T. POPE, Horticulturist

Issued July 9, 1923

WASHINGTON
GOVERNMENT PRINTING OFFICE
1923

HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU.

[Under the supervision of the States Relations Service, United States Department of Agriculture.]

A. C. TRUE, *Director.*
E. W. ALLEN, *Chief, Office of Experiment Stations.*
WALTER H. EVANS, *Chief, Division of Insular Stations, Office of Experiment Stations.*

STATION STAFF.

J. M. WESTGATE, *Agronomist in Charge.*
W. T. POPE, *Horticulturist.*
H. L. CHUNG, *Specialist in Tropical Agronomy.*
J. C. RIPPERTON, *Chemist.*
R. A. GOFF, *In Charge of Glenwood Substation and Extension Agent for Island of Hawaii.*
NELLIE A. RUSSELL, *Collaborator in Home Economics.*

THE ACID LIME FRUIT IN HAWAII.

CONTENTS.

	Page.		Page.
Introduction	1	Spraying appliances	13
Varieties	1	Composition of the lime	14
Culture	4	Commercial products	15
Insect pests	10	Recipes	16
Fungus diseases	12	Summary	19

INTRODUCTION.

The acid lime (*Citrus aurantifolia*) is commonly found growing in both the semiwild and the cultivated state in most tropical and subtropical countries. Some authorities are of the opinion that it is indigenous to India because of its presence in the native vegetation. In the Malay Archipelago, or Malaysia, and other islands of the Pacific Ocean it is grown for home consumption, and in the West Indies, tropical Mexico, and to a lesser extent in southern Florida, it is cultivated for commercial use. The lime was introduced into Hawaii early in the nineteenth century and seems to be the most readily adapted of any of the citrus fruits to island conditions.

The tree has many points in its favor for profitable culture in Hawaii. It can be propagated in several ways, will thrive in a great variety of soils, and produce large crops of fruit during the greater part of the year. Moreover, it withstands drought remarkably well and is not as susceptible to insect attack and disease as are most of the other citrus fruits on the island. The fruit is not imported [1] into Hawaii, and therefore meets with less local competition than do the orange, lemon, and grapefruit.

The fruit has many uses which the orange and lemon can not well serve. The demand for lime juice to improve the palatability of many kinds of tropical fruits as well as for seasoning fish and meat is naturally larger in Hawaii than it is in countries where there is greater variation in temperature. The rapidly increasing population and the widespread demand for the fruit seem to assure local development of the lime-fruit industry and to call for the selection of varieties of high quality for home consumption as well as for the market. At least one lime tree should be grown in every home garden in the Territory.

VARIETIES.

The lime is closely related to the lemon, orange, mandarin, pomelo, and shaddock. Botanically, it belongs to the genus Citrus. It is known by several specific names, being described by various writers

[1] The lime is too tender to be grown commercially in California for exportation to Hawaii.

as *Citrus limetta*, *C. medica acida*, and *C. aurantifolia*, the last of which, given by W. T. Swingle,[2] is the one most generally accepted. Christman calls it *Limonia aurantifolia*, a technical name which includes both the sweet and the sour, or acid, varieties of lime.

Varietal names of limes are really group names in many instances, for they are based on group characters rather than on varietal characters. Many so-called varieties have been described by horticultural writers, but only four, namely, Kusaie, West Indian, Rangpur, and Tahiti, with possibly their closely related species, were experimented with by the experiment station (Pl. I).

KUSAIE.

The Kusaie lime (Pl. I) is said to have been developed on the island of Kusaie, or Strongs Island, Micronesia, by early Spanish settlers. In 1885 it was introduced into Hawaii, where it has steadily gained in favor and is considered the finest of the four varieties of limes tested by the experiment station. The variety reproduces from seed with characters that are superior to those of the parent, is not as thorny as the latter, and does not produce so many seeds.

The Kusaie lime tree varies in size from a mere shrubby bush to a well-formed tree attaining a height of 10 feet (Pl. III, Fig. 1). When allowed to grow naturally the tree develops a spreading, bushy tendency at the top, with lower branches touching the ground; and when reproduced from seed it usually sends up root sprouts which eventually develop into thickets. This latter tendency, however, can be overcome by budding the tree upon some other citrus species which does not send up root sprouts. The Kusaie is evergreen and bears leaves that are rather small in size and somewhat rounded at the apex. It is generally prolific and begins to bear during the second or third year, continuing to produce almost throughout the year.

Fruit: Form, oval, spherical, or oblate; apex flattened or depressed, with a small sharp-pointed nipple; size, medium to large, the diameter ranging from 2 to 2¼ inches; rind medium to thin, light lemon-yellow, and colors irregularly; oil cells numerous; segments vary from 6 to 10; dividing tissues thin; pulp vesicles spindle-shaped; flesh usually of a clear honey-yellow color; juice abundant, colorless or transparent, with a characteristic flavor; central pith usually open; seeds plump and few in number.

All of the Kusaie trees at the experiment station are vigorous and prolific, some of them having started to bear at 18 months of age. In their fourth year these trees each produced about 400 fruits which averaged 40 pounds to the tree. The crop of 1920, 11 years later, amounted to 2,000 fruits per tree, or on the average, nearly 200 pounds per tree. The trees have borne almost continuously since coming into bearing. On May 16, 1922, they were 8 to 10 feet high, heavily laden with fruit, and had spreading tops.

WEST INDIAN.

The West Indian variety, also called the Mexican, Samoan, and Hawaiian lime, is probably the most extensively used lime in Amer-

[2] Standard Cyclopedia of Hort., v. II, p. 782.

FOLIAGE AND FLOWERS OF FOUR VARIETIES OF LIMES: (T) TAHITI; (R) RANGPUR; (K) KUSAIE; AND (W) WEST INDIAN.

KUSAIE LIMES GROWN AT THE HAWAII STATION.

FIG. 1.—KUSAIE LIME TREE. EXPERIMENTAL ORCHARD, HAWAII STATION.

FIG. 2.—LEFT, SHIELD-BUD, LIME ON SOUR ORANGE STOCK. RIGHT, BARK-GRAFT, LIME ON SOUR ORANGE STOCK. BOTH 74 DAYS AFTER GRAFTING.

THE WEST INDIAN LIME WAS THE FIRST VARIETY TO REACH HAWAII. BY MANY IT IS CALLED THE HAWAIIAN LIME.

RANGPUR LIME. GROWN AT THE HAWAII STATION.

BEARSS, A SEEDLESS LIME, AN IMPROVED TYPE OF TAHITIAN.

ica (Pl. IV). It is grown mainly in the West Indies, Florida, and Mexico. This variety is a shrubby bush that attains a height of from 6 to 10 feet. It is well provided with small, sharp thorns, and with rather small, light-green foliage.

Fruit: Ripens practically the year around. Form, oblong to oval; size about 2 or 2¼ inches long (large size range from 1¾ to 2 inches in diameter); surface light lemon-yellow; apex usually smooth with a blunt point when nippled; base usually smooth and occasionally elongated to neck form; rind smooth and very thin; oil cells numerous; segments 10 or less in number and distinctly marked; dividing tissue thin; flesh fine-grained and of light green color; pulp vesicles small and spindle-shaped; juice plentiful and of translucent color; pulp soft to melting; acid very strong, the flavor being distinctly of the lime; central pith open and small; seeds few to many, and in shape flat, like a wedge, to rather pointed.

Several closely related forms grow in Florida.[3] Palmetto, which is the result of a cross between West Indian and the common lemon, and Everglade, the progeny of West Indian with pollen of the pomelo, are said to be excellent fruits. Thornless, another lime of the Mexican type from British Dominica, developed as a sport about 1891. Absence of thorns is a desirable feature in lime culture.

RANGPUR.

The Rangpur, also known as Rungpur or Rungpor,[4] originated in India (Pl. V). Although an acid fruit it is not considered a true lime. It is hardier than the true lime and is said to belong to the Suntara orange group of India. The color of the fruit, the ease with which the peel separates from the pulp and the segments from each other, as well as its peculiar flavor, are characters indicating relationship to the well-known mandarin group of citrus fruits. Owing to the character of the fruit and certain habits of the tree, the Rangpur is grouped with the lime only provisionally. Its introduction into Florida by means of seeds has doubtless been the means of its reaching Hawaii. Several trees of this variety, introduced into Hawaii from Australia by Judge S. B. Dole, have made good growth and are prolific.

The Rangpur lime tree is small and of spreading habit. Its branches are thorny, the foliage is rather sparse, and the small, light-green leaves have rounded apexes but no stipules.

Fruit: In season in fall and winter. Form, round, oblate, tending toward obovate, occasionally necked; apical nipple sharp-pointed; apex usually flat; base depressed at stem, or ridged when necked; size medium with diameter of 2 or 2½ inches; rind inclined to be rough, medium in thickness, easily separated from the pulp, and of irregular color that becomes orange red on ripening; segments regular, 7 or 8 in number, and easy to separate; pulp vesicles large, plump, and pointed; flesh orange-colored; juice plentiful and of an agreeable flavor that is peculiar to the variety; central pith small and open; seeds plump, 7 to 18 in number, with little or no point, and of a greenish hue on the inside.

---

[3] U. S. Dept. Agr. Yearbook, 1905, pp. 279–281.
[4] Hume, H. H. Citrus fruits and their culture. 1915, p. 142.

In 1917 the experiment station received several specimens of Rangpur buds which were grafted upon sour-orange stock. These trees are making such thrifty growth that it is deemed worth while propagating considerable new stock from them for further experiment.

TAHITI.

The Tahiti (Pl. VI) is supposed to be a sport of the Persian variety of lime. The tree attains a height of 15 feet and forms at the top a dense mass of foliage which presents a rounded appearance. The branches are set with small spines and are inclined to droop, and the dark-green leaves are large and have a tendency to curl. The fruiting season of the Tahiti lime is during the fall and winter.

Fruit: Produced in abundance and is borne either singly or in clusters; frequently well hidden by the foliage; seedless; size medium to large, 3 by 2½ inches; apex often nippled with pistil style, or with both stigma and pistil adhering; rind green to lemon-yellow in color, smooth, thin, and scattered with pit depressions; base necked to rounded; calyx adheres firmly to fruit; flesh fine-grained and of greenish color; segments irregular in number but usually average 10; pulp vesicles cylindrical, narrow, and somewhat pointed; juice plentiful, almost colorless, and of agreeable flavor; acid strong; central pith open and small.

Two improved types of the Tahiti are the Bearss and the Improved. Bearss is under cultivation in Hawaii and is highly esteemed on account of the prolificacy of the tree and the large, seedless fruit.

CALAMONDIN.

The calamondin (*Citrus mitis*),[5] erroneously called the Chinese orange, is frequently associated with the lime, for which it is some times used as a substitute.

CULTURE.

CLIMATE.

Lime trees thrive in a warm, moist climate where the rainfall is evenly distributed in frequent showers and varies from 80 to 150 inches annually. In localities where moisture is lacking, irrigation should be practiced to enable the trees to make thrifty growth. It is important that the orchard be relatively free from exposure to the force of high wind, otherwise growth will be retarded, the foliage and flowers seriously injured, and the fruit bruised and scarred. In some places windbreaks are provided to protect a grove that is not well located.

SOIL.

The lime grows best in rich sandy or gravelly soil which is well drained. Porous lava soils of recent formation, geologically, give excellent results when they occur in locations of abundant rainfall. Stiff clay soils are not suitable because they give rise to root troubles. Impervious substrata can be shattered by the use of dynamite.

---

[5] Bailey, L. H. Standard Cyclopedia of Hort., v. II, p. 784.

TILLAGE.

The lime tree makes the same demand upon the soil as do other trees of similar size and the fertility of the soil should therefore be maintained. The soil should be thoroughly tilled to keep it in a suitable condition of aeration and free from weed growth. Such tillage will result in conservation of soil moisture, improvement in texture, and an increase in the productivity of the soil.

FERTILIZING.

To produce the most profitable crop lime trees must be properly nourished. In Hawaii many lime trees do fairly well without tillage, irrigation, or fertilizers of any kind; nevertheless, the fruiting capacity of trees reaching a high degree of productivity becomes abnormal through intensive cultivation, and heavy bearing can be maintained only by furnishing the trees with an abundance of plant food. This may be given in the form of a fertilizing material, either as farm manure or commercial fertilizer, or better still, the two may be used in combination.

Locations naturally differ in soil and climatic conditions and each should be studied separately so that its needs may be determined. As a rule the soil is deficient in humus wherever citrus fruits are grown commercially. Farm manure should be applied to such land or a leguminous cover crop should be grown to furnish green manure. Many growers utilize both.

Farm manure is one of the best general fertilizers. It supplies the soil with a large quantity of organic matter, which, upon decaying, improves the texture of the soil and makes readily available for crop use the mineral fertilizer constituents in the soil. Farm manure should be well distributed over the soil and then immediately turned under.

Green manure is furnished by growing and plowing under some leguminous crop, such as velvet beans, cowpeas, pigeon peas, mungo beans, and the like, which enrich the soil in nitrogenous matter.

Excess of nitrogen in the soil is indicated by vigorous growth of the trees, dark-green foliage, and a small amount of fruit having a thick rind and very fibrous pulp. Liberal applications of potash with the nitrogen tend to produce greater fruitfulness, thinness of rind, and less fiber.

Trees which it is desired to have grow rapidly but which have not attained bearing age require relatively large amounts of nitrogen and much less potash than do those producing heavy crops. Trees bearing heavy crops require a fertilizer having high percentages of both potash and phosphoric acid.

In general fruit culture young trees are thought to require phosphoric acid, potash, and nitrogen in the proportions of 6, 8, and 4 per cent, respectively, and fruiting trees in the proportions of 8, 12, and 3½ per cent, respectively.

Table 1 shows the kinds and amounts of constituents that might be used to make a ton of fertilizer.

TABLE 1.—*Fertilizer mixture for lime trees.*[1]

Constituent.	For young trees.	For bearing trees.
	Pounds.	*Pounds.*
Acid phosphate	800	1,066
High-grade sulphate of potash	314	470
Nitrate of soda	250	.....
Sulphate of ammonia	190	333
Makeweight (filler)	446	131
Total	2,000	2,000

[1] Hawaii Sta. Bul. 9, p. 16.

During 1913–1917 the Department of Agriculture of the island of Dominica, West Indies, conducted fertilizer experiments on lime trees in an orchard that had been abandoned, so far as fertilizers were concerned, for 18 years previous to 1913. The effect of the fertilizers, including cultivation, pruning, and the like, on yield of fruit, is shown in Table 2.

TABLE 2.—*Effects of different fertilizers on yield of lime trees in Dominica.*

Plat No.	Treatment.	Yields per acre in barrels of 4½ cubic feet.[1]			
		1914	1915	1916	1917
1	No fertilizer	23	53	62	88
2	5 tons of grass mulch	14	40	96	110
3	Dried blood, 400 pounds	17	71	98	141
4	Sulphate of potash, 150 pounds	6	28	40	70
5	Sulphate of ammonia, 250 pounds	32	65	99	156
6	Basic slag, 400 pounds	16	37	76	127
7	Dried blood, 400 pounds, with basic slag, 400 pounds	28	89	126	167
8	Dried blood, 400 pounds; sulphate of potash, 150 pounds; basic slag, 400 pounds	24	94	172	165

[1] A barrel of 4½ cubic feet holds about 1,500 limes, which weigh about 150 pounds.

The soils of Hawaii are not necessarily of the same type as those of Dominica, but the results obtained from the above-mentioned experiment show that it is possible to increase the yield of lime trees, although unfertilized for some time, by the application of fertilizers, and that certain fertilizers are more effective than others in bringing about greater yields.

PROPAGATION.

Lime trees may be propagated by seeds, root sprouts, cuttings, layerings, and by grafting and budding. The most general method of propagation is by seed, but results obtained from experiments show that the most practical method for good production is that of grafting and budding.

Seed.—The seed should be well matured, fresh, and well filled. It should be selected from the most vigorous trees and be thoroughly cleaned to reduce the possibility of its being destroyed by insects or by fermentation. After the juice and pulp have been washed from it and superfluous moisture has been removed from the outer coatings, the seed should be planted in shallow seed-sprouting boxes

of sterilized soil and covered to a depth of about one-half inch, or dropped about 2 inches apart in shallow drills laid off 6 inches apart. The sand should then be well packed down. Rich soil should not be used because it is likely to harbor fungus spores, which may attack the seedlings and cause them to die.

Propagating boxes should be kept in a somewhat sheltered place where there is good light and a reasonable amount of moisture. The seed germinates in a few weeks when it is kept at the right temperature and sufficiently moist.

As soon as they are about 2 inches high the seedlings should be separated and transplanted, each to a 3-inch pot of rich sandy loam. An inexpensive pot can be made from quart cans having holes perforated in the bottom to allow for drainage. The holes should be covered on the inside with pieces of pottery or tile to prevent the soil from washing out. As soon as the roots fill the soil the plantlets should be transferred to larger containers. Pot-bound plants are likely to make stunted growth. When they are 10 or 15 inches high, which is usually 10 or 12 months after the seed is planted, the plants should be set in their permanent place in the ground. From 30 to 50 per cent more seeds than are needed should be planted to make allowance for loss or for weak and inferior seedlings.

Root sprouts.—In many countries, particularly where the West Indian or Mexican lime is grown, young trees are obtained by planting root sprouts that are taken from older trees. The Kusaie lime occasionally produces such sprouts in Hawaii. The grower may induce lime trees to send up root sprouts by digging out the surface roots, severing them either wholly or in part from the parent, and planting them with one end left protruding above ground.

Cuttings.—Cuttings of sound, matured wood may be rooted in regular cutting benches. The cuttings should be 6 or 8 inches long, bear several matured buds, and be set firmly in the ground with about 2 inches of the upper ends protruding above ground. Rooted cuttings usually do not have very desirable root systems.

Layering.—This method of propagation consists in removing a ring of bark from a branch just below where it is desired to have the roots start and covering the branch with soil until such time as it has developed new roots. The branch is then removed to its permanent location and established as a new tree.

Grafting and budding.—Methods of grafting and budding have given great satisfaction at the experiment station for rapidly propagating good standard lime trees. (Pl. III, Fig. 2.) Ten and twelve-month-old seedlings attaining a height of 3 to 4 feet and the diameter of a small pencil were used as rooted stocks for grafting purposes. They were repotted several times in the course of a year to promote a steady, vigorous growth, and about two weeks before budding time were given an abundance of water in which a small quantity of nitrate of soda had been placed to improve grafting conditions.

The rooted stock should be vigorous and resistant to adverse conditions if a new-budded tree having health, vigor, and quality is to be established. The varieties of citrus that have given great satisfaction at the experiment station for grafting are the rough lemon, sour orange, pomelo, and shaddock. The station has bearing trees of these varieties which furnish seeds for the production of seedlings for experimental purposes.

Rough lemon seedlings have been employed by horticulturists for some years to meet the need for strong rootstocks for grafting purposes. The main development of this variety has been toward the production of vigorous and resistant rootstocks. The fruit of the rough lemon is rated of poor quality on account of its coarse, thick, rough skin.

The sour-orange stock is produced from seeds of the wild sour orange which now grows in abundance in parts of Florida. Its greatest value lies in its resistant rootstock. Results obtained from experiments indicate that it has about the same value as the rough lemon for propagating purposes.

Pomelo seedlings, or what are commonly known as grapefruit seedlings, make vigorous stock on which to graft the lime.

The shaddock, a fruit of oriental origin, also makes a strong and rapidly growing stock for citrus in Hawaii.

Scions should be selected only from vigorous and prolific trees the fruit of which is known to have a combination of the best qualities that can be found. They should be about three-sixteenths inch in diameter and of green fruit-wood possessing healthy buds, which have not begun to swell with growth.

Of the several forms of union such as shield-budding, bark, side, and whip grafting, that of bark grafting is best. To effect this union the stock should be cut off almost at right angles to the vertical axis and made smooth. A downward slit should be made $1\frac{1}{2}$ inches long, beginning at the top and extending through the bark, to permit of its spreading when the scion is inserted. As soon as the scion is cut the lower portion should be beveled for $1\frac{1}{2}$ inches and the flattened end inserted in the stock between the bark and the sapwood so that the cambium edges will be in proper contact. The union should then be firmly bound with cotton twine or moist tying raffia, and the cut surface sealed with grafting wax to keep out insects, shed water, and prevent the delicate tissues from drying out.

When shield-budding is practiced the shield should be put into an inverted T-shaped incision made in the bark of the stock several inches above the ground. It should then be pushed down until the cambiums are in proper contact, firmly tied in place, and wound with waxed tape for protection. Care should be exercised to raise the bark of the stock without injuring the cambium. The foliaged top of the stock, or a portion of it, should be left standing until the bud has made a growth of several inches. It should then be severed from the stock close to the bud with a slanting cut. The waxed tape should be removed about six days after the operation and the binding string several days later.

Experiments which were made with bark grafting and shield budding at the experiment station showed the former method to be the better of the two in giving a strong union and an early upright growth.

The growth of grafted trees may be continued in gallon containers. The young trees should be exposed to full sunlight so that they will become hardy preparatory to being set permanently in the orchard or home yard. At the end of 10 or 12 months they should be 12 or 15 inches high.

PLANTING.

The lime tree, either seedling or grafted stock, should be at least a year old before it is transplanted to its permanent location. It should be carefully removed from the container with the ball of earth adhering to the roots so that the root system will be injured as little as possible. This can easily be done by inverting the pot and tapping it gently against some solid body. The plant can easily be slipped from the container if the soil is slightly moistened some hours before being taken to the field. If the trees are grown in tin cans tin-cutting shears may be used to open one side of the container to release the roots without injury.

The tree should have an open area of at least 8 feet across and be away from large trees which might shade it and from such vigorous plant growth as would contend with it for food. It should be set in a hole dug fully 2 feet deep with a diameter of 2 feet, be sheltered from strong winds, and be exposed to direct sunlight. Before the tree is planted the hole should be partly filled with loose surface soil which has been enriched with several shovelfuls of well-rotted farm manure. Once the tree is in place the mass of soil adhering to the roots should be loosened a trifle. The roots that have started to grow in a circle should be straightened so that they will grow in an outward direction. Soil should then be filled in against that surrounding the roots and pressed down.

The soil immediately surrounding the tree should be several inches lower than the natural surface to form a slight basin which will hold water until the tree has had ample time to settle. After being planted the tree should be given a thorough watering to induce capillary action of the moisture in the soil. It should then be left alone for several days and after that watered once a week or once in every two weeks. Daily watering is detrimental to growth.

When it is properly planted the tree should stand straight and firm or, if it is exposed to the wind, it should lean slightly toward the direction whence the prevailing wind blows so that it will be able to make a perfectly erect growth when influenced by the wind. The ground immediately surrounding the tree should be kept free from grass, weeds, and shrubbery which would utilize the plant food needed by the lime tree, and the soil should occasionally be stirred to facilitate the release of plant food and keep it sweet.

Seedling trees do not need to be supported with a stake during the first year or two as do other kinds of trees. Grafted trees, however, should be supported and protected with a stake. The only pruning necessary is the removal of dead wood and stray branches which might hinder development.

In orchard planting small lime trees should be set in rows about 15 feet apart each way. This will permit of the growing of 193 trees to the acre. If planted so that the trees in one row come opposite the center of the spaces in adjoining rows a greater number can be grown in a given space.

Young trees may be set in hedge formation and developed into a wide fence. Such a dense row will be invaluable not only as a fence but also for the production of a large quantity of fruit from a small area.

INSECT PESTS AND REMEDIES FOR THEM.

The lime tree is attacked by several insect pests and fungus diseases. In Hawaii it is, however, the least subject to such attacks of all the varieties of citrus. Insect enemies of the lime, with the exception of the Mediterranean fruit fly, may be kept under control by efficient spraying.

FLORIDA RED SCALE (Chrysomphalus aonidum).

The Florida red scale is characterized by its perfectly circular form, shining very dark brown or nearly black surface, and medial lighter dot. Its average diameter is about one-twelfth inch and it appears in great numbers on the underside of leaves and young branches of the lime tree. When infested with it the foliage turns yellow and occasionally the tree dies.

ORANGE SCALE (C. aurantii).

The orange scale is circular and flat in form. The female varies from one-sixteenth to one-eighth inch in diameter, and has a transparent scale through which its red body shows. The male is smaller than the female and of a gray or dark brown color. The orange scale is not as serious a pest on lime as it is on other kinds of citrus trees in Hawaii.

PURPLE SCALE (Lepidosaphes beckii).

The purple scale injures young branches, foliage, and fruits of the lime tree. The female is oyster-shaped, often slightly curved, and from one-tenth to one-seventh inch long and about a third as wide. In color it varies from light brown to rich reddish purple. The male scale is very narrow and smaller than the female.

MEALYBUGS (Pseudococcus filamentosus and P. citri).

Two species of mealybugs (*P. filamentosus* and *P. citri*) have been reported as injuring lime trees to some extent in Hawaii. These insects usually attack the tree in time of drought, and cause the leaves to assume a malformed appearance. These pests may usually be recognized through the distinctive appearance and the peculiar character of their white waxy excretion.

CONTROL.

Kerosene emulsion.—This contact poison is very effective in controlling scale insect pests, mealybugs, and aphids, provided it is sprayed with some force upon the trees infested with them. The following is the formula used for making the emulsion:

Laundry soap	½ pound.
Water	1 gallon.
Kerosene	2 gallons.

The soap should be thoroughly dissolved in water while it is boiling over a fire. When the soap has dissolved the solution should be removed to a safe distance from the fire and the kerosene slowly added to it. The mixture should then be agitated by charging

and discharging for about 10 minutes. When completed the emulsion should be creamy white, thicken on cooling, and show no trace of free oil on the surface. When used the stock solution should be diluted with 8 to 10 parts of water.

Crude oil emulsion.—This emulsion is made in the same way as is kerosene emulsion with the exception that crude oil is substituted for kerosene. Crude oil does not evaporate as readily as do the refined and lighter oils.

San-U-Zay oil.—San-U-Zay oil and water, in parts 1 and 35, respectively, is very effective in controlling aphids and mealybugs. The mixture should be thoroughly agitated by means of a wooden paddle before being applied as a spray. The oil separates when the emulsion is allowed to stand for several days, but the emulsified form is restored by stirring a little salsoda into it.

ORANGE APHIS (Myzus citricidus).

The orange aphis or black fly of the orange is one of the most serious of the pests attacking limes. In late winter or spring many little black-winged flies, or green wingless insects, develop on the young tender growth of the tree. They are usually identified by the honeydew which they excrete on the leaves and stems.

Control.—Tobacco water or nicotine sulphate is commonly used for this sort of pest. A good spray for black flies, mites, and thrips is made as follows:

Nicotine sulphate	1 ounce.
Laundry soap	3 or 4 ounces.
Water	4 gallons.

To be effective the spray must reach every insect.

The measures suggested for the control of the Florida red scale are also efficient in controlling orange aphids. The kerosene emulsion should, however, be diluted with from 10 to 15 parts of water before it is sprayed on the foliage infested with lice and aphids.

COCKROACHES (Eleutheroda dytiscoides).

Cockroaches are occasionally reported as girdling and killing young branches of the lime tree. This species differs from the common cockroach in that the adults are smaller, of a darker brown color, and have smoother wings. They are most commonly found among clusters of leaves or fruits growing in bunches.

Poisoned bait is recommended for use as a control measure.

GREEN CATERPILLAR (Plusia chalcites).

Green caterpillars are the larvæ of small moths which lay an abundance of eggs on the foliage of lime trees. The larvæ appear in great numbers in spring and grow in a few weeks to 1¼ inches long. They may be identified by their method of travel, looping along in much the same way as do measuring worms. They are very destructive to the foliage of many kinds of plants, but especially to that of young seedling nursery stock of the lime.

Control.—As soon as there is any indication of injury from the green caterpillar, an arsenical poison should be sprayed on the plants and trees. A very efficient spray can be made by mixing 1 ounce

arsenate of lead (paste form) with 1 gallon of water, or ½ ounce of arsenate of lead (powdered form) with 1 gallon of water. Arsenate of lead is not only much less likely to injure the foliage than is Paris green but it is also more effective.

FULLER'S ROSE BEETLE (Aramigus fulleri).

Fuller's rose beetle, commonly known in Hawaii as the Olinda beetle, has been found on lime trees in some parts of the Territory. The larvæ live below ground and feed upon plant roots. Upon reaching adult stage they eat the foliage, their method of devouring the margins of the leaves being a means of their identification. The beetles are incapable of flight and their movements are slow. Generally they are nocturnal feeders, but in cooler localities they may be found on foliage during the day. The pest is occasionally kept under control by hand picking and by birds, especially by the myna bird. Arsenate of lead spray has been found useful in their extermination. Carbon bisulphid may, under certain conditions, be used to exterminate the larvæ attacking the roots.

MEDITERRANEAN FRUIT FLY (Ceratitis capitata).

The Mediterranean fruit fly was introduced into Hawaii from Australia about 1907. The adult female is a small yellow fly which lays its eggs in fruit that is nearing maturity. Small white larvæ soon develop and after feeding on the interior of the fruit enter the soil to pupate. After it was introduced into Hawaii the pest spread rapidly and attacked many kinds of fruit. A careful study of this fly has been made by Back and Pemberton.[6]

Control.—Territorial entomologists have done much to control the Mediterranean fruit fly by introducing natural parasitic enemies into the island. About five different species of these natural enemies have, after several years, succeeded in bringing about a great reduction in the ravages of the fly. Lime and other citrus fruits which were formerly severely ravaged are now comparatively free of attack by the fly larvæ. Screens, nets, and paper bags are occasionally used to protect the fruit from this pest.

FUNGUS DISEASES.

BLUE MOLD (Penicillium italicum).

Blue mold is sometimes found on fruit a few days after it is harvested. The spores of this fungus lodge on the fruit in the orchard and germinate when the fruit skin is injured in any way.

BROWN ROT (Pythiacystis citrophthora).

Brown rot is a decaying of the fruit on the tree. The fungus causing the rot lives in the soil and during wet weather develops spores. Affected fruit turns brown and the inner part decays.

ANTHRACNOSE (Gloeosporium limetticolum).

Anthracnose, recently identified on lime fruits in Hawaii by the Philippine Bureau of Agriculture, is a fungus disease which as yet

[6] U. S. Dept. Agr. Bul. 536 (1918).

has not proved serious in the Territory. It usually produces spotting of the leaves and causes them to drop prematurely.

CONTROL.

Fungus diseases are best controlled by Bordeaux mixture.

Bordeaux mixture.—The general formula for Bordeaux mixture is as follows:

Copper sulphate (bluestone)	1 pound.
Quicklime (unslaked)	1 pound.
Water	10 gallons.

The copper sulphate should be suspended over night in a sack in a wooden receptacle, such as a sake barrel or a soja tub, containing a gallon of water. Solution can be hastened by placing the sack just under the surface of the water. If pulverized the copper sulphate may be dissolved in half a gallon of hot water to which an equal quantity of cold water is then added. Make 5 gallons of the copper solution by adding water. The lime should be slaked separately in a small quantity of water. When slaking is completed, add water to make 5 gallons. Equal parts of the lime and the copper should be poured together into a third container and thoroughly stirred when the solution is wanted for use. The solution should then be strained into the spray tank and agitated at frequent intervals to prevent settling of the precipitate, formed by the chemical union of the lime and copper. Bordeaux mixture may be kept without deterioration for some time by the addition of sugar at the rate of one-tenth pound to 10 gallons of solution.

SPRAYING APPLIANCES.

A sprayer of any kind may be used, but for the sake of economy and efficiency it should be such as will produce a fine misty spray. A small pneumatic hand pump having an atomizer type of nozzle will distribute the liquid evenly and be perfectly satisfactory for small nursery seedlings, or for use in yards where there are only one or two trees. The only drawback to such a pump lies in the difficulty of thoroughly spraying the underside of the leaves.

The more complicated kind of pump having an ordinary type of nozzle gives the best results provided the application is liberal and the pressure powerful enough to cause the spray to settle in a fine mist on the trees. Such a pump is necessary where a number of lime trees are grown for commercial use.

A pump having a 5 to 25 gallon tank is useful for spraying small orchards, and the knapsack type of sprayer of this size, when provided with small compressed air pumps, gives considerable satisfaction. The spray flows continuously for several minutes after the air chamber is pumped up and thus the operator is able to give his undivided attention to directing it.

A knapsack sprayer which is equipped with a 3-foot brass extension rod, a stopcock, and a side disgorger of the cyclone type, or an elbow connection for a nozzle of the Vermorel type, has been very effective at the experiment station for use in spraying both sides of the leaves of lime trees.

When 25 or more gallons of material are to be applied at one time the spraying outfit should be mounted on a 2-wheeled cart. Hand pumps and barrel outfits can be drawn by mules, and similar outfits may obtain working pressure if they are operated by chains connecting the pump with the running gear of the gasoline engine or wagon. When considerable work is to be done several nozzles should be attached and operated at the same time.

COMPOSITION OF THE FRUIT.

Fruits of five varieties of limes growing at the Hawaii Experiment Station were analyzed in February, 1922. Tables 3 and 4 give the results of the analyses.

TABLE 3.—*Composition of five varieties of limes growing at the Hawaii Station.*

Variety.	Average weight per fruit.	Proportion of rind and pulp.	Proportion of seeds.	Proportion of juice.	Composition of juice.			
					Total solids.	Reducing sugar.	Citric acid.	Protein.
	Grams.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Kusaie	61.5	39.36	2.29	58.35	9.0	0.81	6.75	0.381
West Indian or Mexican	26.9	44.55	.86	54.59	8.7	.22	7.45	.281
Tahiti [1]	155.0	41.42	.11	58.47	9.5	.77	7.43	.388
Rangpur	84.0	49.2	1.37	49.43	8.4	1.17	6.10	.375
Bearss	124.2	41.22	(2)	58.78	11.6	1.69	8.32	.338

[1] The Tahiti "seedless" lime occasionally possesses some seeds, possibly due to pollination with near varieties blooming at the same time.
[2] None.

Table 4 compares the composition of several kinds of citrus fruits.

TABLE 4.—*Composition of Hawaiian citrus fruits.*[1]

Kind of citrus.	Edible portion.	Waste.	Total solids.	Insoluble solids.	Acid.[2]	Ash.	Protein.	Fat.	Fiber.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Limes	49.17	50.83	11.75	0.11	9.630	0.352	0.675	3.561	0.065
Lemons (rough)	33.14	66.86	6.44	.30	4.753	.232	.356	1.490	.084
Oranges (Kona)	72.13	27.87	12.15	2.57	1.243	.453	.681	.387	.575
Shaddocks	42.39	57.61	11.53	6.14	.276	.486	1.175	.140	1.977

Kind of citrus.	Sugars.			Polarization.		
	Reducing.	Sucrose.	Total.	Direct.	Invert.	Temperature.
	Per cent.	*Per cent.*	*Per cent.*	*° V.*	*° V.*	*° C.*
Limes	1.50	(3)	1.50	−0.4	−0.2	31.5
Lemons (rough)	1.53	0.47	2.00	+2.2	+1.6	32.3
Oranges (Kona)	2.09	3.81	5.90	+3.5	−1.4	28.3
Shaddocks	.86	7.26	8.12	+7.6	−1.6	31.8

[1] From Hawaii Sta. Rpt. 1914, p. 67.
[2] As citric acid instead of as sulphuric acid, as given in the original analysis.
[3] None.

In preparing the samples for analyses the lemons and limes were squeezed to obtain the juice. The oranges and shaddocks were peeled

and the whole pulp was ground. The acid content of the lime is naturally high. The rather high fat content in the limes and lemons was doubtless due to oil from the peel.

COMMERCIAL PRODUCTS.

The growing demand for the various commercial products of the lime has created considerable interest in lime culture, particularly in the West Indies and Ceylon.[7]

Green limes.—The remoteness of the place of production from the general market makes it profitable to ship only especially selected fresh green limes. They are usually packed in barrels holding some 1,500 fruits each. At present the island of Dominica, W. I., which exports about 42,000 barrels annually, supplies most of the world markets with fresh limes.

Pickled limes.—Salt-pickled limes are made from selected yellow fruit, which is steeped in several changes of sea water and then packed in stronger brine at the rate of 2,000 fruits per cask. The demand for pickled limes has been on the decline within recent years.

Raw lime juice.—This product is expressed by passing sound, clean limes between heavy granite rollers. The juice is clarified by being allowed to stand until the albuminous matter forms a precipitate, after which it is filtered and sealed air-tight. It can be kept for several months in this condition without serious loss of citric acid by fermentation. The presence of essential oil from the rind is thought to prevent the possibility of loss of acid, and for this reason, as well as from considerations of color and cost, raw lime juice is not distilled. It is used principally in the preparation of beverages.

Concentrated lime juice.[8]—This product is prepared mainly for the purpose of reducing bulk and consequently freight charges entailed in the shipment of the raw juice. The latter is concentrated to a sirup by the simple process of boiling in a steam-heated or other efficient evaporator, a process which reduces the bulk from one-seventh to one-twelfth of its original volume, the degrees of concentration varying with the strength of the milled juice. Concentrated lime juice is exported chiefly for use in dye works and pure chemical preparations.

Citrate of lime or calcium citrate.—For various reasons citrate of lime or calcium citrate is replacing concentrated lime juice as a commercial product. Great care must be exercised in the preparation of the concentrated lime juice; otherwise a very dark product will result and the crystals of citric acid will be discolored and require expensive purification. Again, leakage from casks and the difficulty of obtaining suitable casks in the Tropics are important commercial considerations.

Citrate of lime, when properly prepared, is a white powder that can be shipped anywhere in paper-lined barrels and it will keep in-

---

[7] Auchinleck, G. G. The cultivation of limes. *In* Trop. Agr. [Ceylon], 57 (1921), No. 5, pp. 284–298.

[8] Information relative to the concentrated lime juice and citrate of lime industry of the West Indies is given in West Indian Buls. 2 (1901), No. 4, p. 308; 7 (1906), No. 4, p. 331; 8 (1907), No. 2, p. 167; 9 (1908), No. 2, p. 193; 12 (1912), No. 4, p. 465; and Agr. News, 1 (1902), No. 7, p. 99.

definitely in storage. At present the preparation of citrate of lime in the country where the fruit is grown is a step in the manufacture of citric acid. The citrate is prepared from clear filtered lime juice neutralized by the addition of chalk or lime. The juice must be hot and the chalk or lime very fine and free from magnesium and other impurities. The chalk or lime is stirred in water to the consistency of cream, after which it is poured into the hot juice, the whole being constantly stirred. When the chalk or lime is added an active foaming or effervescence takes place, which diminishes as the neutralization point is reached. The amount of chalk or lime to be added may be determined by removing a small sample from time to time and testing it by adding more chalk. This is repeated until no active effervescence takes place. Finally, a few drops of lime juice should be added to a sample of the mixture. If only slight effervescence occurs the proper amount of chalk has been added, but if strong foaming takes place more juice should be added to the mixture. The mixture should be heated to nearly the boiling point for a few minutes, when the citrate of lime will begin to fall as a precipitate. The clear yellow liquid is then poured off and the precipitate washed with hot water, after which it is dried and packed for storage and shipment. Commercial citrate of lime contains about 65 per cent of citric acid.

Citric acid is obtained from the citrate of lime by adding dilute sulphuric acid, which produces sulphate of lime, leaving citric acid in solution. The solution is evaporated in leaden boilers until the pure citric acid crystallizes out. Citric acid has many uses.

Essential oils.—A very volatile essential oil of high flavor is obtained from the rind of the lime. The market recognizes two classes of oil, depending upon the method of extraction. The higher grade of oil, or "otto," is extracted from the rind by hand pressure, the fruits being rolled individually on a spiked funnel known as an "écuelle." The method is slow and requires a long time to collect oil in any quantity. After the fruits have been so treated they are milled and the juice and a further yield of oil are extracted by pressure. The oil is then separated from the juice by distillation and is considered as second-grade oil.

Lime oil is in demand for flavoring extracts and perfumery.

RECIPES FOR USING LIMES.[9]

Lime juice makes an excellent flavoring for various kinds of food. In addition to being substituted for vinegar in many recipes, it is used as a seasoning for mayonnaise and the French dressing which is served with many kinds of tropical fruits and in certain kinds of fresh salads. It is also used to improve the flavor of jams, jellies, and fruit butters.

FRESH LIMES.

Sound limes.
Mason fruit jars having air-tight caps.

Select clean, sound fruit which has been cut from the tree in such a way as to leave the little stem-end disks or "buttons" adhering to the fruit. These prevent the entrance of fungus spores which cause decay. To keep limes for several weeks, place them in a fruit jar fitted with air-tight cap.

[9] The writer is indebted to Mrs. N. A. Russell, collaborator in home economics, this station, for recipes 5, 11, 12, 13, 14, and 15, and to H. L. Chung, specialist in tropical agronomy of the station, for recipe 10.

LIMEADE.

2 teaspoonfuls of sugar.
¾ glassful of ice water.
1 lime.

Put sugar in glass, add ice water, and stir until the sugar has dissolved; then add the juice of one lime. Serve immediately. Soda water or boiled water with cracked ice may be substituted for ice water.

GRAPE JUICE LIMEADE.

1 small piece of ice.
Juice of 5 limes.
1 cupful of granulated sugar.
1½ pints of water.
1 pint of grape juice.

Sufficient for six people.

Place ice in pitcher, add lime juice, sugar, water, and grape juice. Stir thoroughly. Let stand for several minutes, then serve.

LIMES WITH ICED TEA.

Hot tea of the strength desired.
Sliced limes.

Serve tea hot with sliced limes and sugar separately to be combined as desired.

LIMES WITH ICED TEA.

2 teaspoonfuls of tea.
2 cupfuls of boiling water.
2 limes.
Crushed ice.

Pour boiling water over tea; let stand for 5 minutes; then strain into glasses half filled with crushed ice. Serve half a lime to the glass and sugar to taste.

AFTERNOON TEA.

3 teaspoonfuls of tea.
2 cupfuls of boiling water.
1 lime.
Cloves.
Candied cherries.
Loaf sugar.

Make the tea in teapot or with tea ball; let stand for several minutes; then serve, placing in each cup a slice of lime pierced with a clove. Add a cherry and serve sugar separately in such quantities as may be desired.

LIME-JUICE COCKTAIL.

4 tablespoonfuls of lime juice.
2 tablespoonfuls of orange juice.
2 tablespoonfuls of sugar sirup.
⅔ cupful of ginger ale.
Crushed ice.

Place ingredients in cocktail shaker; shake, and pour over crushed ice in four cocktail glasses. Serve.

OYSTERS WITH LIME COCKTAIL SAUCE.

4 ripe limes.
3 tablespoonfuls of lime juice.
2 tablespoonfuls of tomato catsup.
1 tablespoonful of finely chopped onions.
12 drops of Tobasco sauce.
½ teaspoonful of grated horseradish.
24 oysters on the half shell.
Salt.

Cut off one-third of each lime, remove pulp and juice, leaving a basketlike container. Mix lime juice with the other seasonings, adding salt to taste. Put the mixture in the baskets and place in the center of deep plates of crushed ice. Surround each basket with six oysters and serve for first course.

LIME WITH FISH.

Squeeze juice of two limes over fish when ready to bake. Add more lime juice while fish are baking, if desired. Garnish with parsley and slices of lime. Serve fish with sauce.

PICKLED LIMES (CHINESE METHOD).

Limes.
Coarse salt.
Granulated sugar.

Large glass jars fitted with air-tight caps.

Wash limes thoroughly; expose them to sun for two or three hours to dry out surplus water; rub salt into limes while they are warm from the sunning, and again once or twice each day for the next four or five days, after they have been exposed to the sun. At the end of that time place salted limes in large glass jars having air-tight caps. Sprinkle surface with coarse salt before placing the cap. Expose the jars of pickling limes to the sunlight for two or more months to cure limes thoroughly before opening jars. When properly cured, pickled limes vary in color from light brown to dark mahogany. When serving, remove the number of limes desired, sprinkle with granulated sugar (one-half teaspoonful of sugar to each pickled lime), and then partly mash. They may be served with meat, rice, and the like.

LIME SIRUP.

(For cold drinks, ice cream, sauce, etc.)

2 dozen ripe limes.
1 pound of cube sugar.

½ cupful of water.

Wash the limes thoroughly in cold water and dry. Rub the sugar vigorously all over the lime until it loses its color. Squeeze the juice on the sugar, add water; then boil and strain. For cold drinks, place 2 tablespoonfuls of the sirup in a tumbler with crushed ice and fill with plain water.

LIMES IN PAPAYA BUTTER.

To every 4 cupfuls of ripe mashed papaya add one-half cupful of lime juice and 2 cupfuls of sugar. Stir constantly over a brisk fire, cooking for 20 minutes.

LIME CAKE FILLER.

4 tablespoonfuls of flour.
4 tablespoonfuls of white sugar.
1 pinch of salt.
4 small limes.

1 cupful of water.
2 tablespoonfuls of butter.
2 eggs.

Sift together the flour, sugar, and salt. Squeeze the juice from the limes, add water, and heat. When boiling, add butter and pour into the mixture of flour, sugar, and salt, stirring well. Add the well-beaten eggs and return to the fire until the mixture is smooth. Place between layers of cake and frost all over.

LIME CREAM-PUFF FILLER.

Make the same as for cake filler (preceding recipe), adding, when cold, one-half cupful of whipped and sweetened cream. Fill the puff just before serving.

LIME PIE FILLING.

6 limes.
1 cupful of water.
4 tablespoonfuls of sugar.

2 tablespoonfuls of butter,
4 tablespoonfuls of flour.
2 eggs.

Wash the limes well, remove a few thin slices of the skin, and chop fine. (There should be a level half teaspoonful of chopped skin.) Squeeze and strain the juice. Boil the water and add sugar, juice, and chopped skin. Melt the butter in a pan, stir in the flour, and add the liquid, stirring until boiling. Place the whites of eggs on ice, beat the yolks, and pour the hot mixture onto them, stirring briskly. Pour into a pie plate lined with pastry and bake until set and the pastry is cooked. Whip the whites to a stiff froth and add a little sugar. Pipe on to the lime mixture and set again in the oven until the filling becomes a delicate brown. Serve either hot or very cold.

LIME CANDY.

4 cupfuls of granulated sugar.
2 tablespoonfuls of lime juice.
½ cupful of water.
2 tablespoonfuls of butter.

Mix ingredients together and cook until a soft ball is formed when tested in cold water. Remove from the fire and beat. Turn into buttered dishes and mark into squares while warm, or knead until creamy and shape as desired.

BOTTLED LIME JUICE.

Limes.
Bottles, 1 or 2 pint capacity.

Extract the juice from the limes, clarify by settling and straining; then fill into bottles and keep tightly corked. The juice can be kept in this way for several months without serious deterioration.

SUMMARY.

The acid lime fruit, which is closely related to the lemon, orange, mandarin, pomelo, and shaddock, was introduced into Hawaii early in the nineteenth century and seems to be the best adapted of any of the citrus fruits to island conditions.

The tree can be propagated in several ways, produces a large crop of fruit during the greater part of the year, withstands drought remarkably well, and is not as susceptible to insect attack as are most of the other citrus fruits.

It thrives best in a warm, moist climate where the rainfall is evenly distributed in frequent showers, and is not particular as to soil type, although it needs rich, well-drained, and thoroughly tilled sandy or gravelly soil for best development.

The lime tree should be furnished with an abundance of plant food in the form of fertilizing material, either as barnyard manure or commercial fertilizers, singly or in combination, to maintain heavy bearing. Vigorous tree growth, dark green foliage, and a small amount of fruit having thick rind and very fibrous pulp indicate the presence in the soil of excessive nitrogen. Liberal applications of potash with the nitrogen tend to produce greater fruitfulness, thinness of rind, and less fiber. In general fruit culture it is thought that young trees require phosphoric acid, potash, and nitrogen in the proportions of 6, 8, and 4 per cent, respectively, and that fruiting trees require them in the proportions of 8, 12, and 3½ per cent, respectfully.

Both seedlings and grafted stock should be at least a year old before they are transplanted to their permanent location. Young trees may be set in hedge formation and developed into a wide fence for the production of a large quantity of fruit from a small area.

Four varieties of limes, with possibly their closely related species, were experimented upon by the station. Of these, Kusaie is considered the finest, having abundant colorless or transparent juice and few seeds. Each tree of this variety produced in its fourth year at this station about 400 fruits averaging 40 pounds per tree.

The growing demand for the various commercial products of the lime has created considerable interest in lime culture. Salt-pickled limes are made from the selected yellow fruit, and raw lime juice is expressed from clean, sound limes and after being clarified is used principally in the preparation of beverages. Green limes are shipped to market, usually packed in barrels holding about 1,500 fruits

each. Concentrated lime juice, which is prepared mainly for the purpose of reducing bulk and consequently the freight charges entailed in the shipment of the raw juice, is exported for use in dye works and pure chemical preparations. Citrate of lime or calcium citrate is replacing concentrated lime juice as a commercial product. When properly prepared it can be shipped anywhere in paper-lined barrels and will keep indefinitely in storage. Citric acid is obtained from the citrate of lime by adding dilute sulphuric acid, which removes the lime and leaves the citric acid in solution. Citric acid has many uses. A very volatile essential oil of high flavor is obtained from the rind of the lime. Lime oil is in demand for flavoring extracts and for perfumery.

The rapidly increasing population and widespread demand for the lime fruit seem to assure local development of the lime-fruit industry.

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
10 CENTS PER COPY

PURCHASER AGREES NOT TO RESELL OR DISTRIBUTE THIS COPY FOR PROFIT.—PUB. RES. 57, APPROVED MAY 11, 1922

▽